On the Structure and Habits of the Polychæta of the Family *Ammocharidæ*. By Arnold T. Watson, F.L.S.

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(Plates 23–25.)

It is a somewhat curious fact that, although the members of this interesting family of tubicolous Polychæta are widely distributed, and some of them abundant, upon the British shores, they have thus far received comparatively slight notice at the hands of British naturalists. Yet almost sixty years have elapsed since Delle Chiaje first brought these worms to light, and figured a specimen in some detail, to which he assigned the name *Owenia*. During those sixty years, contributions towards a full description have, from time to time, been made by Grube, Kölliker, Claparède, von Drasche, McIntosh, Cunningham and Ramage, Gilson, Lo Bianco, and Ogneff, all of which have been ably summarized by de Saint-Joseph in his 'Annélides Polychètes des Côtes de France.' Nevertheless, as much remains to be learnt of their structure and habits, the following notes may perhaps be regarded in part as supplementary to Prof. Gilson's paper, since it was on his suggestion (27. p. 381) that I have paid special attention to certain of the points hereinafter mentioned. They are the result of observations extending over a period of about three years, some of which were made at the Marine Laboratory at Port Erin, whose Director, Prof. Herdman, has rendered me most valuable assistance; the larger part at Sheffield, on specimens obtained from the coasts of Lancashire and North Wales; and also on foreign specimens, both living and preserved, for which I am indebted to Doctors Dohrn and Lo Bianco, of the Zoological Station at Naples.

I also acknowledge, most gratefully, my indebtedness to my friend, Dr. Fauvel, for valuable advice on points of technique and bibliography. The methods of research described in his admirable work, 'Les Ampharétiens,' have frequently been useful to me.

In the absence of an English description of the Ammocharidæ (a family created by Grube), it will perhaps be well, in the first place, to give a general account of their characteristics, embodying my own observations with those of other naturalists, and thereby making the later portion of my paper more intelligible.

The body of the animal is cylindrical, and especially rigid in the anterior portion. It consists of from twenty to twenty-seven segments (Pl. **25**. fig. 20), and varies in length from about 30 mm. in the English to 90 mm. in the Italian species. The diameter at the anterior end measures from 1 mm. to 3 mm. The cephalic segment is slightly swollen and bears a crown of flat, laciniated, tentacular branchiæ, six in number (*b.t.*, Pl. **23**. figs. 1, 2 & 3) (three on either side of the body), which are ciliated on the inner surface. These are absent in the youngest specimens, the mouth being then surrounded only by a funnel-shaped lip, which is quite entire except for a ventral notch. The processes first appear short and squarish in form, with a slight indent on the upper edge, which gives the margin a castellated appearance. In fully-grown living specimens their height somewhat exceeds the diameter of the cephalic segment, but in preserved animals it is slightly less. Each process has a wide, very flat base, giving rise to three or four branches, which are subdivided into seven or more twigs, each terminated by two small rounded mucus-secreting lobes. The crown and branchial processes are well supplied with cœlomic fluid; and in the living specimens the latter have, under favourable illumination, a beautiful appearance, due to the branches from the dorsal blood-vessel and to the network of capillaries with which they are furnished. In British specimens the processes, viewed by transmitted light, are semitransparent, pale greenish blue, or yellow, and tinted with red; whilst those from Naples are blood-red and in parts coloured with a reddish-brown pigment. In cross-section the branchiæ are somewhat horseshoe-shaped, the concave side directed towards the mouth. They are divided into two lateral groups dorsally by a crescent-shaped lobe (*c.l.*, Pl. **23**. fig. 2), which is figured and described by von Drasche (**12**. p. 13) as the head containing the brain. This organ possesses another interesting feature, which seems to have escaped his notice. From his admirable drawings (**12**. pl. i. fig. 3), it would appear that the inner wall of the lobe is in unbroken continuity with the ectoderm. Favourable sections, however, clearly show that this is not the case, and that for a short distance at the apex of the crescent the inner wall is entirely separated from the outer body-wall and forms a kind of ciliated upper lip, which, by means of a network of muscular fibres, can be opened or tightly closed at will (*c.p.*, Pl. **24.** fig. 8). Free communication can be thus established between the cœlomic fluid-containing cavity and the surrounding sea-water. The ventral separation of the branchial processes is, doubtless, a development of what appeared originally as a "notch" in the funnel-shaped lip.

It is interesting to note that one member of this family, *Myriochele* (Mgrn. **4.** p. 211, and **13.** p. 410) is distinguished by the absence of cephalic branchiæ, development of these organs having apparently been checked at an early stage.

During life the interior of the base of the crown is occupied by three lobes (Pl. **23.** fig. 2), namely, the dorsal (*c.l.*), already mentioned, and two lateral ones (*l.l.*) formed by swellings at the base of the ventro-lateral branchial processes, which, distended by the cœlomic fluid, and meeting in the centre, may form more or less completely a kind of vestibule—an arrangement which appears to have hitherto escaped notice. Beneath these lobes, which almost disappear owing to contraction in preserved specimens, is the mouth (*m.*, Pl. **23.** figs. 1 & 3), a transverse opening situate a little distance from the inner dorsal surfaces, the space between the mouth and the ventral boundary being occupied by the peculiar "Lippen-organ" (*l.o.*, figs. 1, 3 & 7), with its massive bilobed lips, first figured by von Drasche (**12.** p. 6, pls. i. & ii.), the functions of which will be hereafter described. The branchial crown is marked off from the "thoracic" region by a reddish-brown fold, which commences laterally and becomes very prominent dorsally (*c.*, Pl. **24.** figs. 7 & 8).

There is a single black or dark-coloured "eye-spot" on the ventral face of the crown (*e.*, Pl. **25.** fig. 20), situate at the base of the branchiæ on either side of the opening.

The segments are neither divided by distinct constrictions, as in *Arenicola* and *Clymene,* nor are they sharply divided from each other; only here and there does the body contour show a slight incurving, indicative of their demarcation (Pl. **25.** fig. 20). The "thoracic region" comprises the buccal segment and three other short segments fused together, the only external indications of which are three bundles of simple yellow, slightly pinnate bristles. Of these, the first two only are visible in the ventral view (Pl. **25.** fig. 20); as the third bundle, consisting of much shorter and less numerous bristles, is situate quite dorsally. Internally there is a septum between the buccal segment and those which follow it, but the next three segments are without septa and enclose a single chamber. The succeeding three "abdominal" segments increase in length, the seventh being sometimes four or five times as long as the buccal and "thoracic" segments taken together. From the eighth segment their length is rapidly reduced, the penultimate segment being very minute. The "thoracic" region and each of the "abdominal" segments is internally cut off from its neighbour by a septum; and with the exception of the anal, the penultimate, and antepenultimate segments, the anterior extremity of each is indicated externally by a bundle of dorsal or dorso-lateral setæ. These setæ are slightly pinnate at the extremity. Each bundle of setæ is followed by a torus, which, in the abdominal region, is so long that the tori (*t.*, Pl. 25. fig. 20) on the two sides almost unite at their extremities, and, at this part, form approximately a complete girdle; though in the last segments the tori will not extend over more than about one-sixth of the circumference. The tori of the first four segments are red owing to the presence of blood. From each torus proceed a considerable number of minute bifid uncini (Pl. 23. fig. 4), which are disposed in very regular, close-set, longitudinal rows (*u.*, Pl. 23. fig. 6); and it has been estimated by de Saint-Joseph (29. p. 401) that there will be about 7600 uncini in a single torus in the third "abdominal" segment. The total equipment of an entire animal is estimated at from 150,000 to 450,000 hooks.

This immense provision of uncini is necessitated by the burrowing habits of the animal, and renders it most difficult to expel the living worm, uninjured, from its tube. The anterior part of each uncinus is preceded by an enlargement, which tends to retain it in the epidermis in which its shaft is buried, though this provision is not always sufficient, as uncini may occasionally be found torn from the tori and embedded between the layers of the inner lining of the tube. Sickly worms, too, occasionally expel their uncini from the mouth of the tube. The shaft of the uncinus is flat and straight, and terminated proximally (Pl. 23. fig. 4, *c*′) by a thread-like elongation, which curves sharply backwards and penetrates the basal membrane. The uncini are actuated by appropriate muscles, and are used for seizing-purposes at will. There are no ventral uncini in the "thoracic" segments, neither are there any dorsal setæ in the penultimate and antepenultimate. The anal segment has no setæ of either kind, and is truncated so that the ventral face, which is terminated by two small lobes (*a.p.*, Pl. 25. fig. 20), extends slightly further than the dorsal. These lobes, as will be seen hereafter, are of special interest. The margin of the anus is ciliated and crenated. In a dorsal, external view of the animal, longitudinal, paired, milk-coloured bands are seen extending as far as the fifth torus (**12**. p. 10). These are due to a thickening of the epidermis. The first pair take their rise laterally, and, curving towards the back, terminate at points against the bundles of setæ of the first torus. From these points there spring a wider pair of bands, which, in the form of bows with their convex sides facing each other, tie together the setæ of the first torus to those of the second. Similar bows bind together the setæ of the three following segments.

An olive-green zigzag canal runs almost from end to end of each of the bands of the second "abdominal" segment (*e.c.*, Pl. **23**. fig. 6). Nephridia have not yet been found in the Ammocharidæ; but it seems probable that these canals, with their internal funnel-shaped mouths and external slit-like openings, represent those organs, though Gilson is mistaken in supposing that they play a part in the emission of the genital products (**27**. p. 379). These, as I shall show, are discharged through characteristic pores at the anal extremity.

A lateral view of the "thoracic" segment shows an interesting point of adaptation of the animal to its mode of life. Von Drasche (**12**. p. 9) has noted the fact that, although the markings are not quite constant, there is, in the dorsal part of the collar, a transverse patch of brown colour, often divided into two portions by the dorsal line. This coloration extends as a line on either side round the fore-edge of the thorax, and swells into the round pigment-spots (eye-spots ?) already mentioned. From these spots the lines descend, and, still going forward, meet at an acute angle on the ventral line, about the level of the first bundle of bristles. He also observes that, in the anterior part of the animal, the course of the nervous system is practically indicated by this coloration; the dorsal patch marking the brain, whilst the lateral lines indicate the œsophageal commissures uniting in the large ganglion, from which springs the ventral cord. This consists of a dotted band, without ganglia or large nerve-fibres, which runs the whole length of the animal.

The entire nervous system is fully described by von Drasche (**12.** p. 13), who observes that it is very rudimentary in character, and lies outside the muscular layer near the surface of the epidermis.

It may be asked whether the localization of the coloration over the nervous system may not be connected with the animal's sensitiveness to light? Some of my sections seem to suggest the possibility, but at present this must remain undetermined. I am able to show that a special function is performed by the triangular ventral area (*v.a.*, Pl. **25.** fig. 20) bounded by the two lines which descend from the "eye-spot." The body-wall is at this point very much thinner than that of adjoining parts, and modified, as I shall show more fully, in relation to the building-habits of the animal.

The structure of the creature is remarkable in many other respects, and for minute anatomical descriptions reference should be made to the papers of Claparède, von Drasche, Gilson, and Ogneff. Speaking generally, I may point out that a cuticular covering to the epidermis is absent, except on the anterior portion of the body; that the underlying circular muscles are limited to the "thoracic" region; and that the longitudinal muscles, which are exceptionally powerful, form throughout its entire length an inner lining for the body-cavity—a layer which is continuous except where it is interrupted by the dorsal and ventral mesenteries of the alimentary canal. These powerful muscles impart considerable rigidity to the fore part of the body; a feature which gradually disappears posteriorly, the thickness of the muscular layer in that part being greatly reduced. According to Gilson (**30.** p. 95) there are no peritoneal parietes distinct from the longitudinal muscular layer, his view being that these two layers are replaced by one musculo-glandular layer which, amongst other things, is excretory in function. This view is, however, opposed by the observations of von Drasche (**12.** p. 20) and Ogneff (**32.**).

A striking and characteristic feature of the Ammocharidæ, which has from the first attracted the attention of naturalists, is the existence in the anterior segments of peculiar, very long, cylindrical, rigid glands (*t.g.*, Pl. **23.** fig. 6) of considerable calibre which hang loosely in the body-cavity. Each is attached to the body-wall by one extremity which, greatly reduced in diameter, forms a minute duct running through the body-wall, opening between the end of the torus and bundle of setæ of that side of the segment to which the gland belongs. There are sometimes seven pairs of these glands, one pair to each of the first seven segments, but those of the third segment may be either rudimentary or non-existent. These are the thread-glands ("glandes filières") of Claparède (**6**), the structure of which has been fully worked out by Gilson (**20**). Their function is to secrete—by exudation from the epithelial cells of the wall of the gland (**20**. p. 317, & **29**. p. 402)—a very thick viscous liquid containing bundles of exceedingly fine colourless threads, which are used by the animal in the formation of the membranous lining of its tube, but not, as some writers have suggested, for the attachment of its external stony covering. The secretion for this latter purpose is supplied by the "Lippenorgan" (*l.o.*, figs. 1, 3, 7 & 9). The œsophagus, which is almost as long as the "thoracic" segment, descends directly from the mouth, and is followed by the intestine, which, with a series of swellings and constrictions, runs straight to the anus.

De Saint-Joseph notes (**29**. p. 403) that in the third and fourth "abdominal" segments the intestine is green owing to the glands which cover it. The alimentary canal passes through the segmental septa, and in addition thereto is supported throughout by a dorsal and ventral mesentery. For the greater part of its length it is surrounded by the dorsal vessel, which forms a peri-intestinal sinus. This sinus bifurcates and leaves the œsophagus on entering the thoracic region. Each branch then goes forward, and, after skirting the nearest group of branchial processes, descends, and, reuniting with its fellow, gives rise to the ventral vessel. Numerous short cæca arise from each side of this vessel, forming round ampullæ, of which de Saint-Joseph states (**29**. p. 403) that he has counted as many as forty in the third abdominal segment. The blood is red. The septa, which are membranous and traversed by fine muscular fibres, have been specially studied by Gilson (**27**). They may completely separate each segment from its neighbour, but by means of valves in the intersegmental membranes intercommunication may be established.

These valves (Pl. **23**. fig. 5) are of two kinds, namely, a simple slit, making a "flap" valve (*f.v.*), opening like a door towards the anterior, which is always situate dorsally; and a sphincter valve (*s.v.*), which is placed ventrally. I have been fortunate enough to see both kinds in action, and note that the cœlomic fluid (in which sometimes ova were floating) almost invariably passed steadily through the sphincter valves when travelling towards the anus, and rapidly past the large slit or "flap" valve when going in the opposite direction. In the absence of assistance from circular muscles, it will be seen that the latter form of valve is specially well adapted for rapid release of the imprisoned cœlomic fluid, and that the animal is enabled speedily to retract the posterior portion of its body, in case of danger, by means of its longitudinal muscles. My observations show that, with the exception of the buccal and "thoracic" segments, and possibly the smaller ones towards the anal extremity, each side of each segment is provided with two valves, one of each kind. Those attached to the septum at the base of the "thoracic" segment are described by Gilson (27. p. 384), and are exceptionally powerful. As will be seen later, this is apparently another adaptation connected with the habits of the animal.

The foregoing will probably suffice as a general description of the structure of the worms, and we may next consider their habits. They are exceptionally hardy animals, whose welfare is apparently more dependent upon a good supply of rather muddy sand than upon a liberal allowance of oxygen, since they thrive under conditions so various as those which prevail respectively on the British shores at low-water mark, and at a depth of 2975 fathoms near the Caribbean Islands (13. p. 410); whilst both Dr. Fauvel and I have found them to live for years in small aquaria destitute of alga and without change of either sea-water or sand, the only attention they received being an occasional raking of the surface and the addition of river-water to compensate for evaporation. They are gregarious, and dwell embedded near the surface of the sand in flexible sand-covered tubes. The tube is unique in structure, and, when fully extended, frequently two or three times as long as its inmate. It is well described by Grube (2), in 1846, as a transparent gelatinous tube, the middle part of which is supported with great firmness by a crust of grains of sand and fragments of shell which, when flat, are "glued" on by their highest edges so as to overlie one another like the tiles on a roof.

Gilson (20. p. 322) has given a most careful description of the minute structure of the tube, and although I am unable entirely to confirm his speculations on the mode of its formation, it is satisfactory to find that his observations on the appearance of the finished tube are quite in accordance with my own, and consistent with what we might expect as the result of the process of building, which I have had the good fortune to witness on several occasions, and shall hereafter describe. From the fact that the sand in the Bay of Naples is singularly devoid of minute flat particles of stone or shell, his specimens would probably not show that most interesting characteristic, "imbrication," mentioned by Grube (2). Gilson consequently does not refer to it; but I know from experience that when suitable material is supplied, these worms gladly employ it in the manner described, and the process by which the desired result is attained is wonderfully ingenious. De Saint-Joseph remarks (29. p. 398) that the fragments of shell are sometimes fixed at a right angle by the edge; but the difference between his description and that of Grube is due to a difference in the state of contraction of the tube at the time of observation. I have frequently seen a tube present both appearances, separated by an interval of, say, half an hour. The tube (Pl. 24. fig. 12) consists of two distinct parts: (1) an external covering of foreign matter (*s.c.*) which may be very minute fragments of shells of molluscs, calcareous tubes of annelids, grains of quartz, or flat particles of other rocks; and (2) an internal tube (*c.t.*) which is translucent, colourless, flexible, elastic, and exceedingly tough—this part being secreted by the worm. The tube as a whole differs, I believe, from all others in that the particles of foreign matter, instead of being more or less attached to one another, are designedly kept entirely apart, firmly affixed only to the inner membranous tube, with the attachment limited to one side or edge (Pl. 24. fig. 12). The structure thus produced is thoroughly protective, and, at the same time, like a coat of mail, it accommodates itself easily to the violent contortions of the body, which are involved in the habits of the worm. Carrying its tube with it, the animal is capable of burrowing through the sandy sea-bottom, and consequently the position of the tube in relation to the surface is by no means constant, though it is usually more or less vertical.

It is interesting to note that the tube itself has an anterior and a posterior end, and is always buried in a definite direction. The anterior, being the growing end (at all events as regards the stony covering), is invariably nearer the surface; whilst the posterior, which never receives additions except to its internal sheath, may be embedded deep in the sand. The membranous tube terminates at each end with a conical, very elastic tip (*c.t.*, Pl. **24.** figs. 12 & 13), which projects more or less beyond the stony covering, and has at its extremity a very minute perforation. At the posterior or buried end, this tip is often preceded by a length of from 10 to 15 mm. of naked tube (Pl. **24.** fig. 13), which Gilson (**20.** p. 322) has mistaken for a secretion at the outset of the animal's existence. It is simply an extension (possibly late in origin) underground, where the worm is unable to affix its stony covering. The animal is capable of reversing in its tube, and thus exploring the sand at either end, and, like the Terebellidæ (**17**), the Ammocharidæ invariably adopt the sanitary method of ejecting the excreta, at the anterior end of the tube, into the open sea.

When the anterior end of the tube of an English specimen is seen under a low power (Pl. **24.** fig. 12), the imbricated arrangement and transparent conical extremity of the internal sheath are very noticeable, the free edge of the bits of stone being directed upwards, whilst the tip, in which is the minute perforation, is drawn in, as is common when the animal is just about to emerge. Gilson (**20.** figs. 21, 22 & 23) gives excellent figures illustrating the structure of the tube. His longitudinal section of the posterior naked end shows that this membranous sheath consists of a number of layers, and that the lengthening of it is produced by internal additions, which advance by stages beyond the extremity of the external ones, each advance being marked externally by a stepped appearance. This section also shows that the tube is occasionally strengthened by new external additions on the face of the layers previously formed.

Both these points are clearly visible in the drawing of this portion of the tube of *Owenia* (Pl. **24.** fig. 13). A cross section shows the internal layers to be concentric. By removing the stony covering from the body of the tube, Gilson demonstrated that the inner sheath is imperforate, and constructed as described from end to end. By means of tangential sections he found (**20.** p. 323), in the wall of the inner tube, a somewhat irregular system of coarse striæ which, under a high power, he was able to resolve into a large number of very fine, irregular, longitudinal striæ, and to recognize as the filaments produced by the thread-glands. Gilson's figure, 23, is specially interesting as delineating a section through the complete tube not stripped of its earthy covering. The section was made by a method specially devised by him for the purpose, and shows both the inner sheath of concentric layers and the outer irregular zone. The former is the part first laid down, as shown in the sections of the tip; whilst the latter is formed of masses of foreign materials subsequently affixed to the former by secretion, in which the various fragments are seen to be more or less completely embedded. My own examination of the structure of the inner tube was made by the ruder method of scraping off the sandy covering, and, after subjecting the inner sheath to maceration in distilled water, tearing the layers asunder. In this way I found it easy to separate the external rugged layer (which represents the cement by which the stony covering is attached) from the tube proper, and, by means of stains, to establish the fact that the fibres in the former (which are embedded in a homogeneous secretion) may assume either a radial or any other direction; whilst those of the sheath take a course which is usually more or less longitudinal or transverse in relation to the tube.

This somewhat lengthy preliminary description will render intelligible the questions to which I have successfully directed my attention. They are as follows:—

(1) The method of construction of the imbricated tube and the elastic conical tips.

(2) The reason for the adoption of this particular arrangement.

(3) The function of the "Lippen-organ" or "Metastomium" (Gilson).

(4) The *raison d'être* of the immense number of uncini and of the double form of septal valves.

(5) The existence of a cephalic opening, and of anal pores.

(6) The method of reproduction.

(7) The larval form (*Mitraria*).

I do not now propose to deal with these questions seriatim, but rather with such points as have not already been dealt with, in my account of the habits of the worm. As already explained, the tube has a definite anterior and posterior extremity, and is usually embedded more or less vertically in the sand, the anterior end being always nearest the surface, and also that to which external stony additions are made. During the day the tube, into which the inmate retreats, is frequently entirely buried; for the Ammocharidæ, like many other annelids, appear to be largely nocturnal in their habits. It is not usually until towards evening that the animal becomes active, and, after exposing ten or more millimetres of its tube above the surface, ventures to protrude its branchiæ.

In order to appreciate the builder's difficulties we must realize the fact that the tube of an annelid is necessarily constructed *from within*; that while it is, so to say, secreted, or built by the worm round its own body, it is so arranged that the inmate shall all the time be entirely detached from it, and free to change its position within it at will. If we imagine the head of the worm protruding through the growing conical tip (*c.t.*, Pl. 24. fig. 12), it will then be seen that, in order to produce the imbricated tube, the base of each new fragment added must be placed carefully underneath the fragments which are already attached, and must be there affixed to the membranous tube; in other words, it must be inserted and fixed between the inner sheath and the last row of fragments added to the outer covering.

Were the process reversed and additions made at the other end of the tube, as by a tiler covering a roof, there would seem to be but little difficulty. The matter would be almost as simple as the placing of one stone above another; but the problem is as I have stated, and its solution (which absorbed considerable time) took me completely by surprise. The beautifully transparent, conical, elastic part of the tube (*c.t.*, Pl. 24. fig. 12), which on retreat of the animal is drawn inwards (the worm thereby frequently pulling together the latest shelly additions and closing the tube with them), is figured as almost fully distended by the water, which is being driven before it by the advancing worm. At first the animal is hidden by the stony sheath, but in another moment the branchial tentacles, contracted and twisted together in the form of a living cone, appear beyond it and fill the elastic transparent tip, which I might perhaps compare to an india-rubber teat. Then, cautiously thrusting the tip of a single tentacle through the terminal pore, the animal carefully feels round to make sure that all is safe. Satisfied on this point, a second tentacle follows the first, then several more; finally the whole branchial crown is forced through the minute opening, and the tentacles, spreading themselves out, cause the elastic sheath, stretched around them like a sphincter, to slip from their outer surface, and settle as a folded ring about the front edge of the "thorax." For a short distance the "thorax" is also visible through, and tightly invested by, the basal part of the membranous cone. The branchial crown (*b.t.*, Pl. **23.** figs. 1 & 2) now appears like a lovely red or golden flower, and, basking in the light, may for a time continue quietly to enjoy the water, which it sets in motion with its tentacular cilia. The expanded tentacles are dorsally widely separated by the cephalic crescent (*c.l.*) into two lateral groups, and just below the outer margin of the crescent a groove, bordered with cilia, is visible.

The ventral division is less apparent, but is marked by the outermost tentacles of each group being, like sentinels, usually slightly advanced within the crown; and whilst the swollen tricuspid lobes (*c.l.* & *l.l.*), with ciliated surfaces, occupy its base (Pl. **23.** fig. 2), the dorsal lobe gently rises and falls as though in the act of breathing. But if the call of hunger claims attention, or a desire for work arises, all is changed. The tentacles become lively, the boughs bend towards each other across the open crown, or perhaps throw themselves violently outwards; opposite twigs incline and meet, whilst the bilobed tips, like miniature fingers, twitch and move as though striving to grasp something. Then, as the water does not supply the need, the worm, in its tube, curves over on one side until the surface of the sand is reached, and that which is desired can be obtained. When the animal is thus seeking sand, or fine particles of shell, these at once adhere slightly to the mucus of the bilobed tips of the tentacles, or are grasped by them and worked into the horseshoe-shaped internal hollow, which, as a ciliated channel, conveys them to the base of the crown. When the sandy particle has in its progress reached the three lobes, one of two things happens: it may either be kept in motion for a short time by the surface-cilia, and then be rejected without apparently having fulfilled any purpose whatever (the two ventral tentacles usually acting as "ejectors"), or, conveyed within the grasp of the lobes, it may be carried down, by a kind of peristaltic action, through the opening into the vestibule beneath. Powerful transmitted light is required to observe what follows, and in this way, with the aid of a suitable arrangement of the microscope and a low power, the fragment can be seen to be now revolving with a jerky motion. It is being manipulated by the "Lippen-organ" (*l.o.*, Pl. 23. figs. 1 & 3, Pl. 24. fig. 7) which, protracted and retracted at each movement, is apparently licking or rasping it, as would the radula of a mollusk. After a few minutes' treatment, the fragment may be ejected by the "Lippen-organ," which, protruding between the lobes, thrusts it upwards, within reach of the ejecting tentacles, which complete the expulsion from the crown. One cannot doubt that, although these worms also swallow fine grains of sand, the process just described is an act of feeding. We may assume that the material last secured, although bearing food upon its surface, was unsuitable for building purposes; but when, by chance, a tempting flat grain of sand, or preferably a minute fragment of shell, is obtained, the "Lippen-organ" assumes a different rôle, namely that of a builder; a function the probability of which was suggested by Gilson (27. p. 381).* The selected fragment is then passed down into the vestibule as before, and there subjected to the treatment just described, but for a much longer period. By this process any available nourishment is doubtless at once removed from the surface, and the material is most carefully cleaned. Then, all being ready, the "Lippen-organ" (*l.o.*, Pl. 23. fig. 1), having turned the fragment into such a position that the thin edge is uppermost, begins to rise steadily, carrying the fragment in front of it. The two lateral branchial lobes separate themselves widely apart to allow of the passage, and the margin of the crown, between the ventral branchiæ, becomes simultaneously stretched.

The upper surface of the "Lippen-organ," with its two bilobed ends, is now visible, carrying the shell, which it intends to fix to the outer side of the tube. In another moment, the position of the fragment is so changed that the flat side, instead of the edge, shall rest upon the "Lippen-organ"; and this continues to rise, until its bilobed extremity is made to project between the lateral ventral tentacles, and to touch the exterior base of the elastic conical tip, which, by retraction of the cephalic segment,

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* In this connection it is curious to note that, at times, the worm appears greatly to prefer building with white materials, and even specimens from Naples (where, to judge by their tubes, only black materials are available) have been noticed to select white when they had the opportunity, and to reject darker ones supplied to them. What means of colour perception such an organism can possess is an interesting question.

combined with a wonderful special arrangement, next to be described, has been brought within reach. I have called attention to the fact (*antea*, p. 235) that a small portion of the body-wall, represented by a ventral triangular area (*v.a.*, Pl. **25**. fig. 20) just above the œsophageal ganglion, is very considerably reduced in thickness. The object of this is now apparent. Simultaneously with the protrusion of the "Lippen-organ," the circular muscles (*c.m.*, Pl. **23**. fig. 1) of the lower part of the "thoracic" segment contract, the powerful septal valves (*t.v.*, Pl. **23**. fig. 1) are doubtless brought into action, and by means of the imprisoned cœlomic fluid a very marked swelling of the anterior part of that segment occurs, especially in the area above referred to, with the result that, at the very edge of the "thorax," a projecting pouch (*t.p.*, Pl. **23**. fig. 1) is produced. It will be borne in mind that the tube (*m.t.*) tightly invests the "thorax," as with a skin, and as it consequently covers the pouch, it assumes its form; and from this it may be realized that the lobes of the "Lippen-organ" (*l.o.*, Pl. **23**. fig. 1), on being protruded, find themselves pretty nearly on a level with the curved upper covering of the pouch. By a muscular action of the upper surface of the "Lippen-organ," assisted by occasional little pushes from behind, the fragment (*f.s.*, Pl. **23**. fig. 1) now commences to travel, sliding along smoothly towards the outer lobes of this, whilst the epidermis on the underside of this end of it is forced upwards and made to take an active part in transferring and affixing the fragment, at a tangent (Pl. **23**. fig. 1), to the curved upper covering of the pouch. This done, the "Lippen-organ" is retracted into the vestibule, the "thoracic" muscles are relaxed, the pouch disappears, and the parts resume their ordinary aspect; but the fragment just added will be found standing vertically, with its base in the required position, and the lower end of its inner side firmly attached to the elastic conical sheath. It is certain that the cement for this purpose is supplied by the "Lippen-organ," which must consequently be regarded as a glandular structure.

From my observations of the habits of the animal, I have no doubt that the external thickening of the membranous sheath is also due to the secretion of this organ, and not, as has been supposed, of the thread-glands. The "Lippen-organ," which is seen *in situ* in the longitudinal section of the "thorax" (*l.o.*, Pl. **24**. fig. 7), is beautifully figured by its discoverer, von

Drasche (12. pl. ii. fig. 3), who describes it (12. p. 6) as being composed of two dorso-ventral lips (facing each other), of which each is bilobed, "in a form similar to that of *Ascaris*"; the dorsal lip being generally rather the larger. In preserved specimens, the two lips are usually found separated from each other by about 180°; but in life they are inclined towards each other at various angles.

Where the bases of the two lips touch there is a small deep fold, which, however, is cæcal and does not lead into the body-cavity. The organ is retracted by means of a local folding of the centre of its cup-shaped membrane.

Von Drasche adds (12. p. 12) that the organ is a folded portion of the epidermis, consisting of high, wedged-shaped, badly staining, ciliated cells, with small nuclei. As regards preserved specimens, I shall not attempt to improve upon this excellent description, except to question the existence of the ciliated nature of the cells, at all events as regards the upper surface of the organ. I have seen it at work many times, and although I have observed ciliary action on the dorsal lobe and other parts, I have failed to detect anything of the kind on its surface. On the contrary, the impression, conveyed by watching the living animal, is that the function of these tall, transparent cells is the secretion of the cement for attaching the outer stony covering and strengthening the membranous tube. In certain operations, which I hereafter describe, the ventral end of the organ is protruded between the ventral tentacles, so as to bend far over the edge and manipulate the outside of the membranous tube. On such occasions the organ presents a beautiful semitransparent appearance, with the two protruding terminal lobes, tensely distended as from pressure of the secretion with which they are charged. A transverse section (Pl. 24. fig. 9) of this end of the "Lippen-organ" shows that the clear, tall cells, which are so noticeable on the upper face, have disappeared from the under, and given place to much shorter nucleated cells and a folded arrangement of the epidermis (*l.c.*). From the way in which the latter structure is protruded, and takes part in the operations of the animal, I have no doubt that some of the secretion is discharged from its surface, probably near the centre line, below the ventral end of the organ, although a discharge may also take place from the upper surface, as is clearly shown in the central fold of one of my sections.

The contents of the first two pairs of thread-glands, like those of the long cells (*h.c.*, Pl. 24. fig. 9) of the "Lippen-organ," strongly resist stains, and it seems very probable that their secretions are identical. The fact that the secretion of the "abdominal" thread-glands stains more readily, may possibly indicate some difference in composition.

The membranous conical tip (*c.t.*, Pl. 24. fig. 12) is a characteristic and essential feature of the tube, and in the event of its accidental removal it is at once re-formed by the worm. By taking advantage of this fact, I have been enabled to make two very interesting observations on (1) the method by which the membranous tube is formed, and (2) the means by which the animal can easily, at will, cut off any desired portion. The latter is a habit which I had noticed to exist, from frequently finding fragments in the aquarium cut off evenly as though with a knife; showing that the worm possesses some special means of accomplishing the apparently difficult task of cutting through the tough membranous sheath. In order to make sure of these observations, a healthy vigorous worm was selected, carefully removed from the aquarium, and placed in sea-water in a glass dish. The tube, as usual, was considerably longer than the animal, and to induce work I at once cut off enough from each end to reduce the tube to about the length of the tenant, taking care, of course, not to injure the worm. This, in its shortened tube, was then transferred to a shallow glass dish containing fresh sea-water, and watched under the microscope. Very soon the animal became aware of the unusual "draughtiness" of its dwelling, and proceeded to investigate the position by cautiously protruding its tentacles and examining the edge of the tube. Having ascertained the extent of the damage, and by repeated search satisfied itself that no enemies were near, it retired just within the shelter of the tube, so that the tips only of the branchial tentacles were, now and then, visible at the fractured end. By transmitted light, it was just possible to see between the sand-grains, and through the membranous tube, that something was going on inside: the branchial tentacles were more or less completely twisted together; the worm was revolving slowly within its tube, with the first bundle of setæ in motion, and it occasionally advanced slightly and then retreated. This process continued for varying periods (apparently dependent upon the intensity of the light), which sometimes extended over an hour or more; and then a swelling of the tube suddenly commenced, at a point about a millimetre distant from the fractured end. This internal swelling gradually separated the sand-grains far apart, and, through the interstices, it could be seen that the branchial tentacles were tightly screwed together to form a solid living cone, and that the fore part of the "thoracic" segment was so fully distended by the cœlomic fluid, that all trace of a division between it and the base of the branchial crown had disappeared. The worm kept up a constant revolving motion, the bristle-bundles being actively at work, whilst, between the ventral tentacles, both ends of the "Lippen-organ" (*l.o.*, Pl. 23. figs. 1, 3, & 7) simultaneously rasped the membranous tube, their ventral lobes striking downwards, and their dorsal lobe vigorously pulling in the opposite direction. In a few minutes the tube was in this way burst and cut through, the severed part or ring being gradually thrown off by the tentacles, which, quietly unfolding themselves one by one, withdrew from the interior and passed the ring over their tips. Freed from the stony encumbrance, the branchial tentacles were seen to be naked and fully exposed to the water; but careful illumination showed that the "thoracic" segment was once more invested with a new membranous, tightly-fitting covering, so beautifully transparent as to be almost invisible, and this I found to be the foundation layer for the new conical tip. It had been formed while the animal was sheltering and revolving in the old tube; the necessary secretion being doubtless supplied by the first two pairs of thread-glands, and passed forward, by and over the tentacles, which, as I have stated, were screwed together so as to form a conical mould. On one occasion, a tentacle was seen to be extended beyond the rest, as though to form a pivot to keep the minute aperture at the tip of the tube open. Immediately the tentacles were freed from the stony ring, the animal proceeded to complete the formation of the membranous tip. It advanced so far in its tube that the whole of the branchial crown was exposed, and the new tip, as a transparent skin, was fully stretched over the "thoracic" segment. Then, for the space of five minutes, the first two bundles of bristles worked vigorously, like brushes, spreading the cement which, with accompanying violent contortions of the body-wall, was poured out by the thread-glands, the animal meanwhile keeping up a constant, steady revolution within its tube. Then the edge of the new tip (and sometimes the interior) was manipulated by the underside of the ventral end of the "Lippen-organ," and the animal once more retired into the stony tube. It was found that a beautifully perfect, though apparently delicate tip had been produced. After a short interval the other end of the tube was similarly renewed.

The part taken by the setæ in this operation is, I think, noteworthy. It has hitherto been overlooked, and as I have witnessed it in the tube-forming operations of *Panthalis* (24) and *Nerine*, it is probably true of other annelids. Although it was impossible, owing to the stony covering of the tube, to see what was taking place low down, there can be no doubt that the action, as regards the "abdominal" thread-glands, would be a repetition of what I have described. Gilson's interesting experiment shows that a marked exhaustion of the contents of the thread-glands results from the repairing and extending of a fractured tube. As already stated, the lengthening of the tube is due to constant additions, internally, of new membranous tips, the old layer always being forced outwards; consequently, the description of the formation of the membranous tip is really a description of the formation of the outer layer of the completed tube. As I have shown, it is due to the secretion of the thread-glands of the "thoracic" segment, supplemented by those of the "Lippen-organ." Its outer coating, during the life of the animal, is quite unaffected by the sea-water, and it is obviously impossible for it to be renewed. It is an interesting fact, however, that the tube as a whole, though exceedingly tough during the life of the animal, speedily decomposes after its death or expulsion; and it would seem probable that during life a constant renewal of the internal layers is taking place, and that these (which are doubtless due to the secretions of the larger glands) differ, in composition, from those of the outer sheath—a probability which is also indicated by the difference in the reaction to stains already alluded to.

The tube is essential to the existence of the animal, which, when in great straits, bending its body into the form of the letter S, will make a tube only one third of its own length suffice temporarily for its protection; but if, by chance, the worm should be expelled from the tube, death will follow after a short time, as the animal is then, like the Serpulidæ and some other worms (19. p. 75), evidently quite incapable of replacing it.

The Ammocharidæ are generally regarded as "sedentary worms," but, from what has been said in the earlier part of this paper, it will have been gathered that their habits are not entirely of that character. Members of this family are, in fact, capable of burrowing in their tubes through the sand; and although this is usually done without travelling far afield, still they are quite capable of working their way through a considerable thickness to the surface, or of leaving the sand entirely, and reburying themselves in new sites. Experiments made with the object of learning something of these habits, have elicited interesting facts. When the worm is first captured and exposed, say by digging and rapidly washing away the sand by means of a sieve, it is generally found that the tube is of considerable length, firm and swollen at the part where the worm at the time happens to be, but diminishing to the diameter of thin twine in the unoccupied portion. In English specimens, the large proportion of fragments of shell in the outer sheath imparts a striking whiteness to the tube. A ball of sand, loosely held together by mucus, is commonly found covering the short length of otherwise naked tube at the posterior extremity. This is, doubtless, formed by the branchial tentacles. From the nature of the building-operations, it is obviously impossible for the "Lippen-organ" to properly affix sand-grains underground, though there is ample evidence, in the form of imprints (*d*, Pl. 24. fig. 13), that this organ strengthens the membranous tube by external additions of its secretion. If such a tube be left in sea-water, without sand, it will be found, after an interval of an hour or two, that it has entirely changed its appearance, and has become spindle-shaped, and only one half or even one-third of its original length. The worm, having drawn over itself the portion which was previously unoccupied, has thus caused the fragments of shell or sand to come more closely together and stand at right-angles to the length of the tube. If the specimen be now reburied beneath a few inches of sand, it will be found, after a short interval (varying of course with the thickness of the layer), that it has burrowed upwards, so as to bring the anterior end of its tube to the surface, a position which is apparently needful for its welfare; and when it is remembered that, in doing this, the free edges of the external fragments have been so placed as to meet with the greatest resistance from the surrounding sand, it will be realized that the operation involves great muscular exertion. The necessity for the unusually ample equipment of uncini in the "abdominal" region, in order to carry the tube with the body, is thus explained.

The rate of burrowing is not, of course, rapid when a considerable thickness of sand has to be penetrated, ten hours being required, under favourable circumstances, to bore through 150 mm., though 20 mm. would be run through in a few minutes. As the tube is very similar in colour to the sand in which the animal dwells, observation upon its displacements was at first impossible; but, by the admixture of a sufficiently large proportion of white (Calais) sand, I ultimately ascertained the burrowing act to consist of a combination of an undulatory with a screwing motion. When engaged in this operation, the animal occupies the anterior end of the tube, the conical tip of which is filled by the densely-packed tentacles; while the first row of shelly fragments, spread out, possibly forms a cutting edge. By twisting the anterior portion of the body and tube round in the sand, the animal practically converts them into a short hollow screw, about 10 to 15 mm. in diameter, which, working somewhat spasmodically at intervals of a minute or two, to afford time for rest and stretching the tube, gradually makes its way to the surface. On reaching this, the action of the worm confirms the observation in a very curious manner, as, in order to get the desired length of tube exposed, it bends hard over, and pressing on the surface of the sand, describes another revolution with its anterior end, which results in a further stretching of the tube, accompanied by the formation of a saucer-like hollow in the sand. It will be noticed that I speak of stretching the tube; and in explanation I may state that, as a rule, the animal does not carry the whole tube bodily with it to the surface, but attains its end by causing it to stretch the required distance. In some of my experiments, a tube apparently only 65 mm. long stretched to a length of 200 mm., but when again uncovered contracted to its original dimensions. Occasionally, however, the animal, for the purpose of changing its habitat, quits the sand, and in this case it brings the whole tube with it. This is an act which probably sometimes costs the animal its life, for McIntosh states (**10**. p. 103) that *Owenia filiformis*, with its gravelly tube, is a favourite food of haddocks, cod, and flounders. In order to re-bury itself, the worm reverses its position, and, protruding the branchial tentacles through the opening at the posterior end of the tube, proceeds to force them into the sand. In this operation it is assisted by the "Lippen-organ," the ventral end of which, acting very much like the foot of a mollusk, strikes over the edge of the membranous tube, and so, with its underside, digs a burrow in the sand, enabling the animal gradually to screw itself downwards. The "thoracic" setæ also appear to take part in this work. This operation is much slower and more laborious than the upward burrowing, and the animal not unfrequently cuts off, and leaves on the surface, a portion of the tube. The tube is thus re-embedded in its natural position; and it is very unusual indeed to find a tube in which a change in the direction of building has taken place, though I am bound to admit this occasionally occurs.

With reference to the method of reproduction, Claparède (**6**), von Drasche (**12**. p. 20), and Gilson (**30**. p. 99) have respectively described the formation of the sexual elements as taking place on the walls of the ventral blood-vessel, in the tissues which clothe the longitudinal muscles, mesenteries, and blood-vessels, and on the inner face of the musculo-glandular tissue, of which the last-named author considers the body-wall of *Owenia* to be composed. All agree that the elements are shed into the body-cavity, that they float about in the cœlomic fluid, and are frequently found, apparently straying, in the "thoracic" and buccal segments. The means of their escape from the body-cavity is unknown, though Gilson (**27**. p. 370) confidently suggests that the "epithelial canal" in the second "abdominal" segment is the natural outlet. Starting from this standpoint, I have directed my attention, firstly, to observing the movements of the ova when they appear in the cephalic segment; and, secondly, to ascertain in the living animal the mode of emission of the sexual elements, and the early life-history.

By the first line of research I failed to secure the information I desired, namely, as to the fate of the ova in the cephalic segment, though it resulted in the discovery of the interesting, and probably unique structure for a Polychæte, the opening of the cephalic lobe (*c.p.*, Pl. **24**. fig. 8). Although this structure is exceptional in the Polychæta, a similar prostomial pore is met with in some Oligochæta (Enchytræidæ), a fact to which Mr. E. S. Goodrich has kindly called my attention. Upon this point Beddard makes the useful contribution that "the dorsal pores are missing without exception in those Oligochæta which live in water; but these latter worms have a pore upon the head, which appears to be wanting in the earthworms." He adds that "Dr. Michaelsen has thought that the head-pore serves to relieve the brain-pressure—to act in fact as a kind of safety-valve for the liberation of superfluous fluid" (26. p. 349). From what we know of the habits of the Ammocharidæ, it is clear that if ever such provision be needed, it would be in their case. But to continue my notes:—For several days a large Italian specimen in the desired condition was under observation, and it was noticed that the number of ova in the segment varied, increasing and diminishing, and extending even into the bases of the branchiæ, and ultimately almost entirely disappeared, without any apparent cause. Occasionally a considerable number were congregated near the centre of the groove in the cephalic lobe, and it was expected that a discharge would take place at that point, but nothing of the kind occurred. The observations and sections, therefore, simply show that, at the point indicated, there is an opening into the cœlom, guarded by a network of muscular fibres (some of which may be free, protrusible processes), and the ova may be either aerated at that point, or make their escape there under compression or when disintegrated. As to which is the more likely, I will not venture to say, though the ova which reach this spot are, apparently, so few that it cannot be supposed that all in turn pass into this segment and return to the "abdominal" segment, though this is possible. The emission of ova from the "epithelial canal" was watched for in vain; in fact, only once did a worm emerge sufficiently for its tube to expose the opening of these ducts, though, when reburying the tubes, it sometimes happened that a sufficient length lay naked in the sand.

Fortunately, the solution came at last. On the evening of May 23rd, 1898, a large living specimen from Naples, which had settled in a small aquarium, protruded from the anterior end of its tube about 20 mm. of the posterior portion of its body, and for the space of about ten minutes discharged spermatozoa in two white, smoke-like streams, which issued from tubular openings on the ventral wall (right and left) of the anal extremity. During the discharge the animal waved its tail-end vigorously from side to side, thus assisting dispersion. The cloud of spermatozoa at first settled down, as a white layer, on the surface of the sand, but in the course of about half an hour nearly all had disappeared. The spermatozoa (Pl. 25. fig. 19) were found to be of the form figured by von Drasche (12. pl. ii. fig. 14). Three other specimens in the same aquarium, with branchiæ fully displayed, were apparently quite unaffected by what was taking place; and this observation was one evening in the following July supplemented and confirmed by a colony of English specimens which had, a few months before, settled in another aquarium. About 7.30 p.m. several males discharged spermatozoa, the swarms of which were still close to their respective tubes, and readily recognized by the cloudy masses speedily diminishing. Shortly afterwards, several followed exactly the same course, and about the same time three females discharged ova. The latter procedure differs somewhat from the former, in that little more than the anal extremity is exposed from the anterior end of the tube. A quantity of fæcal matter was first expelled, and then the ova were, as before, discharged through the two pores at the anal extremity, but much more slowly than the spermatozoa and enveloped in albumen, so that while issuing the discharge had a thread-like appearance. When deposited, there was formed a small jelly-like mass near the tube; and the contrast between the energetic movements of the male and the quiet discharge of the female was very marked. In one case a male, whilst discharging spermatozoa, actually stirred-up with his tail a mass of ova which had been deposited by a neighbour. With very few exceptions, all the worms discharged their genital products within an hour or two, and as to the cause of this simultaneous action it may be that the swarm of spermatozoa from the first animal which discharges acts as a stimulus. Hornell has observed (22. p. 13) similar synchronous emission in the case of *Branchiomma vesiculosa*.

A few days after spawning, nearly all the worms cut off about 10 mm. of the anterior end of their respective tubes. The anal pores (*a.p.*, Pl. 25. fig. 20) are very striking and interesting structures, their lumina being lined with very large, regular, radiating, cylindrical, transparent cells (*a.p.*, Pl. 24. figs. 10 & 11), which refuse stain when treated with hæmatoxylin and eosin. Possibly their function may be glandular and connected with the supply of albuminous matter, since they appear to be most fully developed in, if not entirely confined to, the females. I have been unable definitely to determine at what stage in the animal's development these cells first appear. I have failed to detect them in the youngest specimens (only 10 mm. long), which were obtained by the kindness of Dr. Herdman from Naples; but I found them fairly well developed in other specimens (only 16 mm. long) which, though probably only a few weeks older, were full of ova. In order to reach these pores, the genital products pass through the sphincter septal valves (*s.v.*, Pl. **23.** fig. 5), which can easily be traced in the sections right up to the lumina of the pores. On one occasion, whilst examining a preserved *Ammochares* from Naples (which in 90 per cent. alcohol had not become hardened), I accidentally caused these pores to open and work by osmotic action, the specimen having been transferred to spirit of a different strength.

The ova, deposited on the 17th July 1898, were examined every 24 hours and sketched from life from the 19th to the 21st inclusive (Pl. **25.** figs. 14–18). On the second day, the eggs were in the morula stage, and a few specimens, which had been transferred from the aquarium to a small glass dish, had, on the 20th July, attained the two different forms represented by figs. 15 & 16, Pl. **25.**

In view of the subsequent development, it is interesting to note that, whilst watching the specimen fig. 16, I observed, now and then, a thread or two, with a cell at the extremity of each, shot forth from the point (*m'*), the threads being immediately retracted. Fig. 15 is also deserving of special attention, since it corresponds, most closely and suggestively, with a stage in the development of the Hydrozoa, as shown in Fewkes' figure of *Agalma* (**11.** pl. iii. fig. 12) of somewhat similar age. It was found that development had been retarded by removal, as specimens taken the same evening from the aquarium had reached the stage with characteristic setæ, fig. 17, which will be recognized as *Mitraria.* On the following evening, the specimens in the glass dish were found dead, and those in the aquarium, although vigorous, had apparently made little or no further progress in development. The larva attached itself by its setæ to the bottom, and, using them as a pivot, rotated in a top-like fashion in the watch-glass, whilst four others, affixing themselves by the same means to a speck of floating organic matter, in the form of a cross, caused it to revolve like a miniature wheel. This rotation was doubtless due to cilia at the apex of the bell, as the motion of those at the margin was scarcely perceptible.

When making my sketches, I had neither seen Metschnikoff's nor any other figures of *Mitraria*, and I had constantly to wait until the animal returned to its original position: to this fact is due the omission in fig. 18 of the two crescent-shaped thickenings of the epidermis figured by Metschnikoff (**7.** pl. xviii. fig. 8), as although they were seen distinctly when drawing other parts, no subsequent view enabled me to give their exact form and position.

Upon comparing the figures (17 & 18) with those of Metschnikoff (**7.** pl. xviii. figs. 5 & 8), the chief difference relates to the outline of the ciliated margin of the hydrophyllium; that of my specimen was perfectly plain, and, when seen from below, somewhat oval in outline, whilst Metschnikoff's figures show the margin to be deeply lobed. That Metschnikoff's *Mitraria* is the larval form of a species of *Ammochares* there can, I think, be little doubt. Its agreement with that of the English form, *Owenia*, is exceedingly close.

The lingual organ of the young worm, figured by Metschnikoff (**7.** pl. xviii. fig. 12), agrees closely, both in form and position, with that of *Ammochares*, whilst the position of the "schleimabsondernde Organe" corresponds with that of part of a "thread-gland." The form of the uncinus (**7.** pl. xviii. fig. 12 A) is unmistakably that of the family, though Metschnikoff's figure of the worm (**7.** pl. xviii. fig. 12) shows only a *single* row of uncini to each of the "abdominal" segments. The anterior smoothly truncated end of the worm, shown in his figure, corresponds with what might be expected from Cunningham and Ramage's observation (**15.** p. 656) that, "in small specimens the mouth is surrounded by a funnel-shaped lip, quite entire, except for a ventral notch," and that "it is only in the larger specimens that the branched processes are seen." Metschnikoff's statements (**7.** p. 241) that while each of the first three segments of his young worm bore on either side a bundle of fine tapering setæ only, all the other segments were equipped with both setæ and transverse rows of uncini; that the first eleven segments were extraordinarily long, and distinguishable only by the arrangement of the bristles, since the usual segmental cross-furrows were absent; and that the last body-segment ended with two roundish little lobes, between which was the anal opening (points all in striking agreement with the structure of the Ammocharidæ), convey, in combination with his figure, what apparently is an accurate description of a young *Ammochares*. It will doubtless be admitted that these facts completely refute the suggestion of Häcker (**31**. p. 15), based mainly upon the form of the bristles, that *Mitraria* should be regarded as related to the *Hermellidæ*.

Further study of the early stages of development will certainly yield an ample reward. The imperfections of the present account are largely due to the fact that I was striving to rear the larval forms, and consequently hesitated to kill any of the specimens. My observations were made in the summer of 1898, and, unfortunately, the efforts which I made in the two following years proved abortive.

The Ammocharidæ have a very extended range, viz., the Arctic Ocean (Spitsbergen), North Sea, Mediterranean, Adriatic, Davis Straits, the Antilles, Brazilian seas, Japanese seas, and the Philippines.

De Saint-Joseph (**29**. p. 404) has called attention to their connection with the Maldanidæ on the one hand, and the Serpulidæ on the other; whilst Gilson has emphasized many of the interesting points in their structure, and argues (**30**. p. 90) that the absence of muscular rings from the greater part of the body and the existence of the two longitudinal mesenteries are characteristics of inferiority, and recall the Archiannelids, a contention which, adopting Meyer's view of "Annelid Descent" (**18** *b*. p. 1147), appears to be supported by the discovery of the anal outlets for the genital products, and also by the exceptional larval forms.

LIST OF WORKS CITED,

arranged in order of appearance.

1. DELLE CHIAJE, S.—Descrizione e Notomia degli Animali invertebrati della Sicilia Citeriore, Tav. 175, tom. i. p. 35 (1841).
2. GRUBE, E.—Beschreibung neuer oder weniger bekannter Anneliden. Arch. f. Naturgeschichte, 12. Jahrg., 1846.
3. KÖLLIKER, A. von.—Kürzer Bericht über einige im Herbst 1864, an der Westküste von Schottland angestellte, verg.-anat. Untersuchungen. Würzb. Naturw. Zeits. Bd. v., 1864.

4. Malmgren, A. J. — Annulata Polychæta Spetsbergiæ, Grönlandiæ, Islandiæ et Scandinaviæ, hactenus cognita. Œfvers. af K. Vet-Akad. Förh. 1867, No. 4.

5. McIntosh, W. C.—On the Structure of the British Nemerteans and some new British Annelids. Trans. R. Soc. Edinb. vol. xxv., 1868.

6. Claparède, E.—Les Annélides chétopodes du Golfe de Naples. Mém. Soc. Phys. et Hist. Nat. Genève, t. xx., avec suppl. (1870).

7. Metschnikoff, E. — Ueber die Metamorphose einiger Seethiere (*Mitraria*). Zeit. f. wiss. Zool. vol. xxi., 1871.

8. Claparède, E.—Recherches sur les Annélides sédentaires. Mém. Soc. Phys. et Hist. Nat. Genève, t. xxii., 1873.

9. Marion, A. F.—Sur les Annélides de Marseille. Revue des Sc. Nat. Montpellier, t. iv., 1875.

10. McIntosh, W. C.— Marine Invertebrates and Fishes of St. Andrews. 1875.

11. Fewkes, J. W.—On the Development of *Agalma*. Bull. Mus. Comp. Zool. Harvard College, vol. xi. (1883–85), pl. iii. fig. 12.

12. Drasche, R. von.—Beiträge zur feineren Anatomie der Polychaeten. Zweites Heft: Anatomie von *Owenia filiformis*. Wien, C. Gerolds Sohn, 1885.

13. McIntosh, W. C.—Report on the Annelida. 'Challenger' Exp., vol. xii. pp. 410–413 (1885).

14. Eisig, H.—Die Capitelliden. Fauna und Flora des Golfes von Neapel, xvi., 1887, p. 336.

15. Cunningham & Ramage.—Polych. sedentaria of the Firth of Forth. Trans. R. Soc. Edinb. vol. xxxiii., 1888.

16. Gilson, G.—On Secreting Cells. Report of the Brit. Assoc. 1890 (Cardiff).

17. Watson, A. T.—The Tube-building Habits of *Terebella littoralis*. Jour. Roy. Microsc. Soc. 1890.

18. Meyer, E.—(*a*) Die Abstammung der Anneliden. Biol. Centralblatt, Band x., 1890. (*b*) Translated in the 'American Naturalist,' vol. xxiv., 1890.

19. Soulier, A. Études sur quelques points de l'Anatomie des Annélides tubicoles de la région de Cette (Montpellier). 1891.

20. Gilson, G.—Les Glandes filières de l'*Owenia fusiformis.* La Cellule, t. x., fasc. 2, 1893.
21. Lo Bianco, S.—Gli Annel. tubic. del Golfo di Napoli. Atti dell' Accad. delle Scienze di Napoli, 2 ser. t. v., 1893.
22. Hornell, J.—Method of Ova-dispersion in Tube-building Worms. Jour. Marine Zool. & Microscopy, vol. i. p. 13 (1893).
23. Gilson, G.—On the Septal Organs of *Owenia fusiformis.* Rep. Brit. Assoc., Ipswich, 1895.
24. Watson, A. T.—Observations on the Tube-forming Habits of *Panthalis Œrstedi.* Port Erin Biol. Station. 1895.
25. Benham, W. B.—"Polychæta." The Cambridge Natural History, 1896, p. 325.
26. Beddard, F. E.—"Oligochæta." The Cambridge Natural History, 1896.
27. Gilson, G.—Les Valves septales de l'Owenia. La Cellule, t. xii., fasc. 2, 1897.
28. Fauvel, P. — Recherches sur les Ampharétiens. Bull. Scientif. du Nord de la France et de la Belgique, tom. xxx., 1897.
29. Saint-Joseph, de. — Annélides Polychètes des Côtes de France. Ann. Sci. Nat. sér. 8, tom. v. (Zool.), 1897, pp. 397–405.
30. Gilson, G.—Cellules musculo-glandulaires paroi du Corps et fonction excrétoire de l'Owenia. La Cellule, t. xiv., fasc. 1, 1898.
31. Häcker, V.—Die pelagischen Polychaeten und Achaetenlarven der Plankton-Expedition. Ergebnisse der Plankton-Expedition der Humboldt-Stiftung, Bd. ii. H. d. p. 15 (1898).
32. Ogneff, J.—Prof. Gilson's "Cellules musculo-glandulaires." Biol. Centralblatt, xix. (1899). Jour. Roy. Micr. Soc. 1899, Part 2 (April), p. 159.

EXPLANATION OF THE PLATES.

Reference Letters.

a., anterior extremity. *a.p.*, anal pores. *b.*, brain. *b.t.*, branchial tentacles. *b.w.*, body-walls. *c.*, collar. *ch.*, bristle-bearing process. *c.l.*, cephalic lobe or crescent. *c.m.*, circular muscles. *c.p.*, cephalic pore. *c.t.*, conical tip of tube. *d.c.*, intestine. *e.*, eye-spot. *œ.*, œsophagus. *e.c.*, epithelial canal. *f.s.*, fragment of stone or shell. *f.v.*, flap-valve. *h.b.*, epidermal band. *h.c.*, high cells of Lippen-organ. *l.*, under-lip. *l.c.*, shorter cells of Lippen-organ. *l.l.*, lateral lobe. *l.m.*, longitudinal muscles. *l.o.*, Lippen-organ. *l.r.*, upper-lip. *m.*, mouth. *m.t.*, membranous tube. *p.*, posterior extremity. *s.*, setæ. *s.c.*, stony covering of tube. *sp.*, septum. *s.v.*, sphincter valve. *t.*, torus. *t.g.*, thread-gland. *t.p.*, thoracic pouch. *t.v.*, "thoracic" septal valve. *u.*, uncini. *v.a.*, thin ventral "thoracic" area.

Plate 23.

Fig. 1. Diagrammatic section of *Ammochares*, illustrating method of forming the imbricated tube.

2. *Ammochares filiformis.* Cephalic segment viewed from above, showing the internal lobes (*c.l.* & *l.l.*) as they would appear during life. This is a restoration of fig. 3.

3. *Ammochares filiformis.* Cephalic segment viewed from above (von Drasche), showing the "Lippen-organ" (*l.o.*) and mouth (*m.*), which are frequently visible after death owing to contraction of the three lobes.

4. Uncini of *Ammochares*:—
    a′. *Ammochares assimilis*, Sars (**4.** Pl. xii.).
    b′. „ *ottonis*, Grube (**5.** Pl. xv.)
    c′. „ *fusiformis*, D. Chiaje (**29.** Pl. xxii.).
    d′. Uncinus of *Mitraria*, Metschnikoff (**7.** Pl. xviii.).

5. Diagrammatic vertical section of a posterior segment of *Ammochares*, showing the action of the septal valves (*f.v.* & *s.v.*).

6. Dorsal view of second "abdominal" segment of *Ammochares*, showing the zigzag epithelial canal (*e.c.*) in the lateral bows; also (in dotted outline) the form and position of the thread-glands.

Plate 24.

Fig. 7. Vertical longitudinal section of anterior extremity through centre line of *Owenia filiformis* (English), showing, ventrally the "Lippen-organ" (*l.o.*) *in situ* when at rest; and dorsally the cephalic lobe, with indication of cephalic (prostomial) pore (*c.p.*). × 45. (From a thick section.)

Fig. 8. Vertical longitudinal section through centre of cephalic lobe, showing the brain (*b.*) and cephalic (prostomial) pore (*c.p.*) with its transverse muscular fibres. *Ammochares filiformis* (Naples). × 100.

9. Transverse section of ventral end of "Lippen-organ," showing the tall, clear secreting-cells (*h.c.*) and the underlying folded structure (*l.c.*). *Ammochares filiformis* (Naples). × 100.

10. Horizontal section through the anal lobes and pores (*a.p.*) of *Ammochares filiformis* (Naples). A deep section, showing the internal radiate arrangement of cells lining the pores. × 100.

11. Horizontal section, showing glandular structure of cells and lumina of anal pores (*a.p.*). *Ammochares filiformis* (Naples), ♀. × 100.

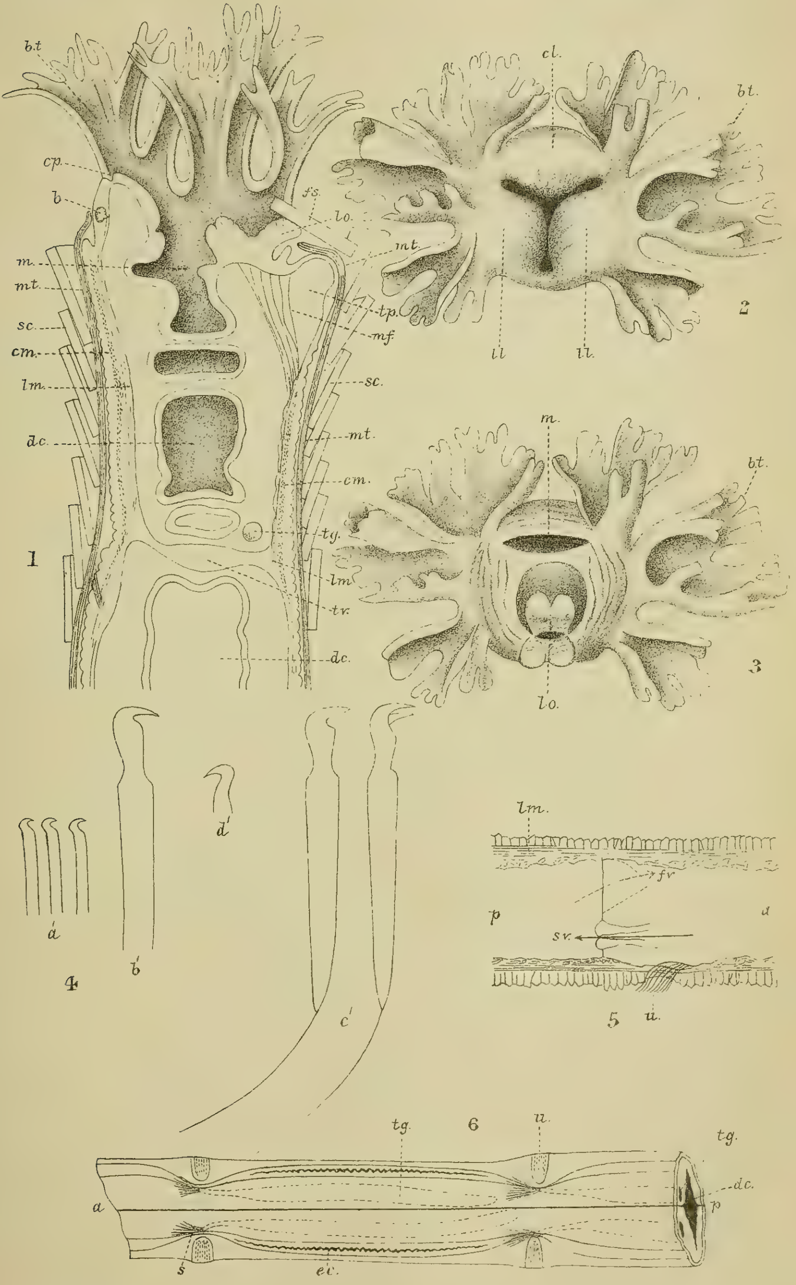
12. Anterior or exposed end of tube, showing the clear elastic tip of inner sheath, and the imbricated arrangement of the external stony covering (*s.c.*). *Owenia filiformis* (English).

13. Posterior or buried membranous end of tube of *Owenia filiformis* (English), showing its telescopic construction and consequent external stepped appearance; also the strengthening of the wider part by external disc-like additions (*d.*). × 22.

PLATE 25.

Figs. 14, 15 & 16.—Stages in the development of the larva of *Owenia filiformis.*

Fig. 14. The embryo 48 hours after discharge of ova.
15. ,, 72 ,, ,,
16. ,, 72 ,, ,,
17. Larva of *Owenia.* Lateral view 96 hours after discharge of ova = *Mitraria.*
18. The same, viewed from beneath.
19. A ripe spermatozoon of *Owenia.*
20. *Ammochares filiformis* (Naples). Ventral view. × 2. (From a preserved specimen.)



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M.P. Parker lith.

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STRUCTURE OF THE AMMOCHARIDÆ.

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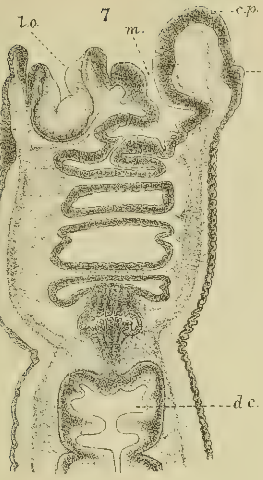

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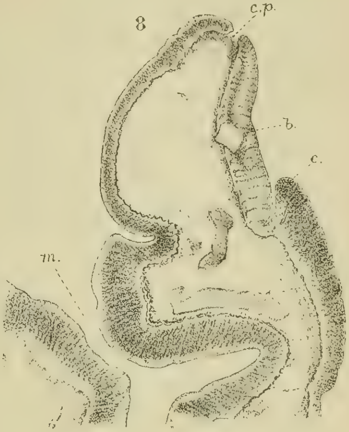

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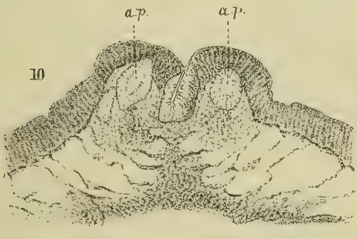

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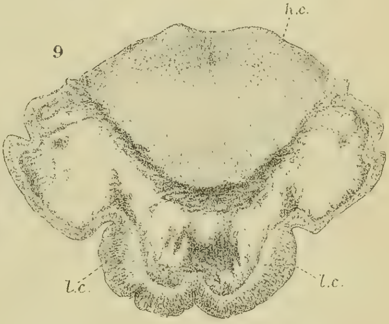

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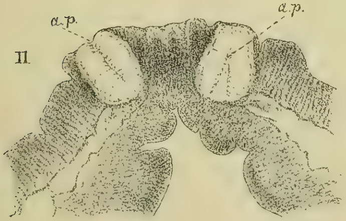

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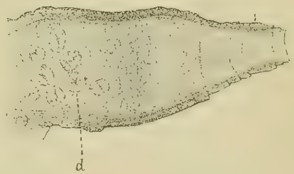

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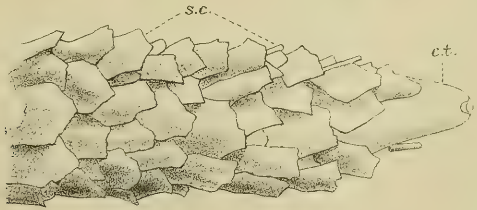

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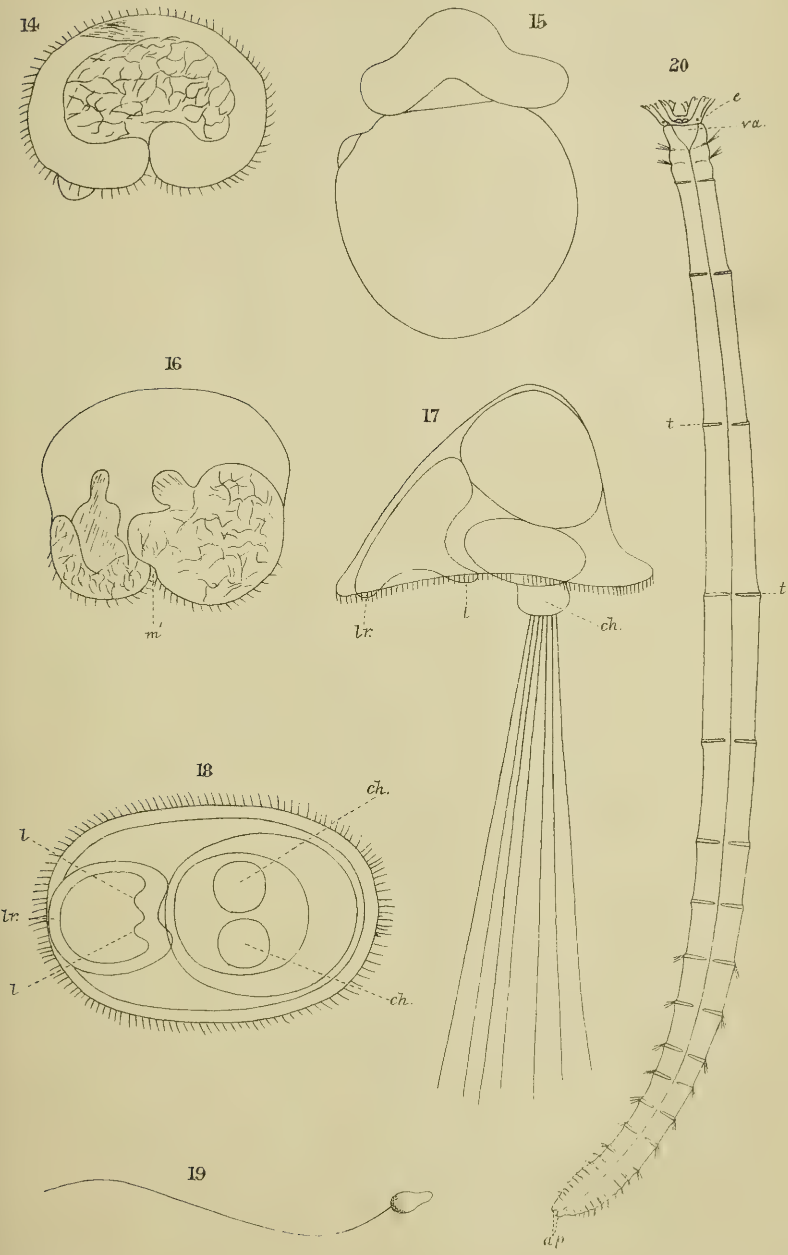

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AMMOCHARES & DEVELOPMENT OF OWENIA.